ECOLOGICAL SUBSECTIONS OF CAPE KRUSENSTERN NATIONAL MONUMENT

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Introduction

There has been increasing interest in inventory and monitoring of natural resources in National Parks, Monuments, and Preserves in Alaska. However, the choice of where to sample is difficult due to the large area involved. One useful strategy is to stratify sampling by ecosystem regions, to ensure adequate coverage of all ecosystems and economical allocation of the sampling effort. The purpose of this ecological unit map is to aid sampling for inventory and monitoring studies in Cape Krusenstern National Monument, Alaska (Fig. 1).

The guiding principle in definition of ecosystem regions is that ecosystems consist of the sum of the biotic and abiotic environment, and meaningful boundaries can be drawn that separate zones of relatively uniform ecological conditions (Bailey, 1996; Rowe and Sheard, 1981). Because the various tiers of the ecosystem (geology, landforms, soils, vegetation, etc.) are linked, they tend to change together and can be used in concert to define and map ecosystem regions.

Ecosystem regions (or "ecological units") defined by the above approach can be delineated at various scales, from tiny microsites to global-scale regions. The system of units used here was developed for mapping by the U.S. Forest Service and consists of the numerous levels, intended for use at different scales (Table 1). As discussed below, the units in the present study are *Subsections*, subdivided further into finer units where possible.

Ecological units delineated at the scale of this study are complex mosaics with many different kinds of vegetation and soils. A particular kind of vegetation or soil may occur in more than one unit; for example, cottonsedge (*Eriophorum vaginatum*) tussock tundra on wet soils with permafrost occurs as a component of many of the ecological units recognized here. However, the exact set of components in an ecological unit, their relative area, and their location on the landscape is unique for each unit. In other words, each unit consists of a mosaic of vegetation, landforms, and soils that is consistent and different from all the other units.

Because this map and write-up are based entirely on remotely-sensed data interpreted during a few weeks in the winter of 2000-2001, they should be considered preliminary. Use of the map and its verification by fieldwork should lead to refinement of boundaries, subdivision or amalgamation of units, and more comprehensive map unit descriptions.

Methods

The ecological units were delineated following the basic principles outlined by Bailey (1996) and Wertz and Arnold (1972). Ecological units were recognized by qualitative interpretation and synthesis of the available data for the study area, using the author's knowledge of what is ecologically important. Quantitative methods (e.g., map overlay and statistical analysis) were not used directly to define the ecological units or draw boundaries, although these methods were used to produce descriptive tables for the ecological units. These ecological units are best thought of as hypotheses about what constitutes ecologically significant regions in the study area, hypotheses that can be tested against any data that may be collected there in the future (Rowe and Sheard, 1981).

According to Bailey (1996), ecological units delineated at the scale of the present study (1:250,000) generally coincide with geologic or geomorphologic features. While geologic and geomorphic features typically determine the boundaries between ecological units in this study, the purpose was not to produce a geologic or geomorphologic map. Instead, the scale of these features and their close linkage to biotic features make them the best basis for mapping ecological units.

Ecological units were delineated in ArcView 3.2a (Copyright 1992-2000, Environmental Systems Research Institute, Inc.) using as base maps satellite imagery (Thematic Mapper image 10 Aug 1990, path 81, row 13) and US Geological Survey Topographic Maps (a digital raster graphic mosaic of 1:250,000 and 1:63,360 scale maps). The on-screen scale used when locating polygon vertices by clicks with the mouse varied from about 1:50,000 to 1:100,000, with the purpose to produce boundaries that are accurate and smooth at 1:250,000 scale. Because of the scale of mapping, line placement is accurate to within about 250 m. Users should be careful when enlarging the map to scales larger than it was drawn (i.e. larger than 1:100,000). The two base maps (topographic and satellite image) were alternated frequently to check the location of boundaries against both topography and surface reflectance.

Boundaries were drawn by mentally synthesizing the basemap information with data from the following references:

High-altitude color-infrared aerial photographs (1:60,000 scale, 1978-1980) viewed in stereo for landforms and vegetation;

- Geologic maps (1:250,000 scale) for major bedrock (Beikman, 1980) and surficial (Karlstrom *et al.*, 1964) geologic features; and
- Land cover maps (Markon and Wesser, 1998) from Thematic Mapper satellite imagery classified into 20 vegetation and other land cover classes.

In response to the needs of the expected users of the maps, ecological units were delineated as finely as the methods would allow. Ecological *Subsections* were delineated and named by conventions outlined in Cleland *et al*. (1997). Most of the subsections could be readily subdivided into more detailed units. However, not all of these more detailed units are fine enough to qualify as the next level down in the National Hierarchical Framework of Ecological Units, the *Landtype Association* (Table 2; Cleland *et al*., 1997). Furthermore, field sampling would be needed to verify the composition of any landtype associations. Thus the finer units are here referred to simply as "detailed ecological units".

Ecologic units that occurred in the National Park were extended beyond the park boundary to their natural limits. Placement of ecologic unit boundaries outside of the park should be considered tentative.

After ecological unit boundaries were finalized, the ArcView polygon shapefile was converted into an ARC/INFO 8.0.2 coverage. The coverage contains 72 polygons, classified into 13 subsections and 27 detailed ecological units. The fields in the polygon attribute table of this coverage are:

AREA	polygon area in units of decimal degrees
PERIMETER	polygon perimeter decimal degrees
*#	ARC/INFO's internal polygon identification number (* depends on the coverage name)
*-ID	user-option polygon identification number (* depends on the coverage name)
PARK_CODE	four-character NPS abbreviation for the park unit or units where the polygon occurs
ECOREGION	from an unpublished map by G. Nowacki, P. Spencer, T. Brock, M. Fleming, and M. Torre Jorgenson, 6/2000
SECTION_NA	full name for the ecological section
SUBSECT_CO	symbol for the ecological subsection
SUBSECT_NA	full name of the ecological subsection
DETSUB_CO	symbol for detailed ecological unit
DETSUB_NA	full name of detailed ecological unit
PHYSIOGRAP	physiography (landform) descriptor
LITHOLOGY	lithology (rock or sediment) descriptor
MANUSCRIPT_LINK	name and section of html document, to be used as a hotlink field in ArcView.

Soil and permafrost information is somewhat speculative, based on aerial photograph interpretation of vegetation and landforms, Holowaychuk *et al*. (1966), Lachenbruk *et al*. (1966), and the author's experience in similar regions elsewhere in Alaska. Patterned ground is usually not visible on the aerial photographs used, but the types most likely to be present are given under "soils" in the ecological unit descriptions. For more information on arctic patterned ground, see Washburn (1956, 1979), and Zoltai and Tarnocai (1981), and Williams and Smith (1989). Vegetation information in the map unit descriptions is based on the land cover classification of the Monument by Markon and Wesser (1998), interpretation of aerial photographs, and Johnson *et al*. (1966). Land cover information in the tables was computed by ArcView overlay of the ecological units onto the land cover map. The elevations in the map unit descriptions were computed by ArcView overlay of the ecological units onto the 90 m Digital Elevation Model of Alaska.

Ecological Unit Descriptions

The map legend for ecological units of Cape Krusenstern National Monument is given in Table 2. The criteria used to delineated the subsections are summarized in Table 3. For areas of the land cover classes composing the subsections and the total area of each subsection, see Table 4.. Mean climatic data for Kotzebue (near sea level, about 12 km from the southeastern tip of the study area) are given in Table 5. For units that range outside of the National Monument, the elevations in the descriptions below are for the portion of the unit that falls within the Monument boundaries only.

A simplified map of subsections in Cape Krusenstern National Monument is given in Fig. 2. For locations of the detailed ecological units, see the ARC/INFO coverage that accompanies this report.

ACP Aukulak Coastal Plain Subsection

The Aukulak Coastal Plain Subsection. Numerous shallow thermokarst lakes are visible. Vegetation on higher areas between the lakes is mostly cottonsedge tussock tundra. July 10, 2001; roll 4, frame 11.

Detailed ecological unit in the Aukulak Coastal Plain Subsection:

ACP1 Aukulak Coastal Plain - 114 km^2
(area within the Monument boundaries)

ACP1 Aukulak Coastal Plain

Geology and Physiography: nearly level region with numerous thermokarst lakes in various stages of growth, drainage, and succession after drainage. Sediments consist of old glacial deposits and old coastal marine deposits, probably mostly fine-grained and reworked in thermokarst lakes.

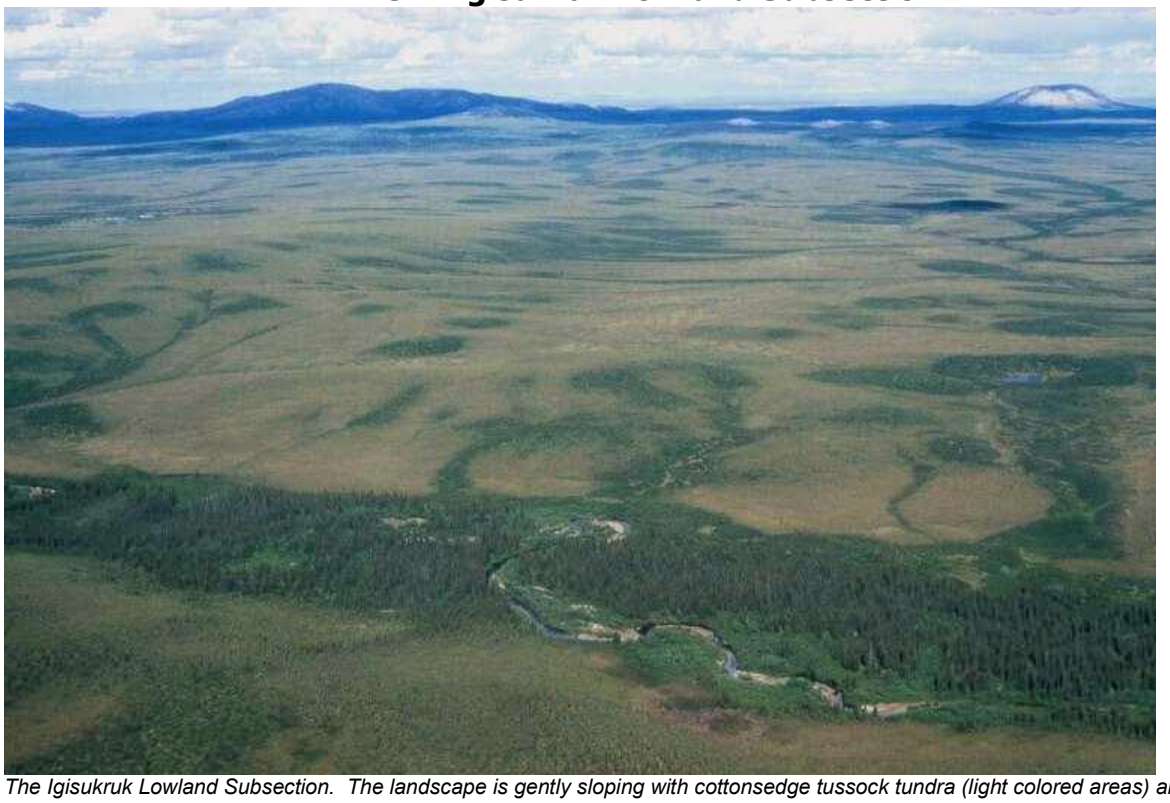
Elevation: 0 to 78 m (0 to 256 ft)

Soils: wet, fine-grained soils with a thick organic surface layer and permafrost near the surface predominate. The organic layer is thinner and the active layer is temporarily thicker in recently drained lake basins. A thinner organic surface also probably present on slightly convex surfaces between lakes. Ice-wedge polygons are probably common.

Vegetation/land cover: slightly higher, convex areas have tussock and low shrub tundra. Depressions have mostly wet sedge vegetation.

Notes: See the Imikruk Plain for information on the thaw lake cycle.

IGL Igisukruk Lowland Subsection



The Igisukruk Lowland Subsection. The landscape is gently sloping with cottonsedge tussock tundra (light colored areas) and low shrubs (brighter green areas). The Igisukruk Creek Floodplain (in the foreground), which supports a strip of spruce forest, is also in this subsection. July 10, 2001; roll 4, frame 7.

Detailed ecological units in the Igisukruk Lowland Subsection:

IGL1 Igisukruk Creek Floodplain - 3 km^2

IGL2 Igisukruk Lowland - 49 km^2

(areas within the Monument boundaries)

IGL1 Igisukruk Creek Floodplain

Geology and Physiography: floodplain and young terraces of a small meandering river. Sediment is probably mostly derived from limestone.

Elevation: 9 to 30 m (30 to 98 ft)

Soils: soils are highly variable depending on proximity to the river, age of the surface, and vegetation. Well-drained, coarse-grained soils with a deep active layer and thin (< 20 cm) surface organic layer appear to predominate. Some older and higher surfaces may have finer-grained and wetter soils with permafrost nearer the surface and a thicker surface organic layer.

Vegetation/land cover: mostly open spruce forest or open or closed low shrubs. Some tall shrubs also present.

Notes: this floodplain appears to be the only floodplain with significant occurrence of spruce in the study area. Cold summer temperatures and high winter winds have probably prevented spruce from colonizing floodplains further west and north. Spruce groves also occur on protected sites in the uplands to the north.

IGL2 Igisukruk Lowland

Geology and Physiography: low hills with long gentle slopes, probably composed of old glacial deposits and slope deposits derived from Paleozoic sedimentary rocks. Includes two low but distinct bedrock-cored hills outside of the study area to the east.

Elevation: 0 to 74 m (0 to 243 ft)

Soils: probably moderately wet, loamy soils with active layer up to about 1 m thick and surface organic horizon present but probably 20 cm or less in most places. Mudboils (nonsorted circles) are probably common.

Vegetation/land cover: mostly open low shrub tundra, with some tussock tundra. Closed low or tall shrubs occur along drainages.

Notes: parts of this lowland is probably a pediment (i.e. an extension of the Igichuk Pediment) but it probably has a thicker mantle of colluvium. The southwesternmost part looks like a ridge of old glacial till. Slopes are gentler and soils probably wetter than on the Igichuk Pediment.

IHF Igichuk Hills, Forest-Tundra Subsection

The Igichuk Hills, Forest-Tundra Subsection. Note the patch of spruce forest on the right at the foot of a barren limestone hill. Light colored areas on the left are cottonsedge tussock tundra and dark green areas in the foreground are mostly low shrubs. July 10, 2001; roll 4, frame 16.

Detailed ecological units in the Igichuk Hills, Forest-Tundra Subsection:

IHF1 Igichuk Pediment, Forest-Tundra - 81 km^2
(area within the Monument boundaries)

IHF1 Igichuk Pediment, Forest-Tundra

Geology and Physiography: rounded hills mantled with colluvium from Paleozoic sedimentary rocks, probably mostly limestone. Several distinct bedrock domes project above the otherwise rather gentle surface. Bedrock is probably present within a few meters of the surface on most convex and planar surfaces.

Elevation: 14 to 305 m (46 to 1001 ft)

Soils: probably moderately wet, loamy soils with gravel; the active layer is probably about 1 m thick or less in most places and surface organic horizon present but probably 20 cm or less. Convex hill crests probably have gravelly soils with a deeper active layer (> 1 m) and thin or no organic surface horizon. Mudboils (nonsorted circles) are probably common.

Vegetation/land cover: gentle, convex slopes have tussock and open low shrub tundra, with shrubs more abundant than in the "Igichuk Pediment, Tundra" unit. Patches of spruce forest occur on favorable sites: mostly south-facing footslopes of the bedrock knobs, where soils are relatively dry and warm due to coarser texture, slope, and exposure to the sun. Drainages have closed low or tall shrubs.

Notes: pediments are slopes with a thin veneer of colluvial deposits (unconsolidated material moving downslope) over bedrock. The colluvium is derived from hill crests where bedrock extends into the active

layer (over most of this unit the bedrock is permanently frozen). Colluvium is also derived from adjacent bedrock outcrops in the Igichuk Hills units. For a discussion of pediments in the arctic see French and Harry (1992). The patches of spruce forest in this unit are the largest in the study area. Cold summer climate and high winter winds probably have prevented forest growth further to the west.

IHT Igichuk Hills, Tundra Subsection

The Igichuk Hills, Tundra Subsection. (Upper photo) The Igichuk Hills, Steep are low mountains that are largely barren limestone that rise out of the Igichuk Pediment, Tundra. July 10, 2001; roll 4, frame 14. (Lower photo) The Igichuk Pediment, Tundra covers most of the photo, with the Igichuk Hills, Steep in the background. Vegetation is mostly cottonsedge tussock tundra (lighter color) and low shrub tundra (darker color). July 10, 2001; roll 4, frame 19

Detailed ecological units in the Igichuk Hills, Tundra Subsection:

IHT1 Igichuk Hills, Rounded - 53 km^2
IHT2 Igichuk Hills, Steep - 88 km^2
IHT3 Igichuk Pediment, Tundra - 419 km^2
IHT4 Kakagrak Hills - 40 km^2
(areas within the Monument boundaries)

IHT1 Igichuk Hills, Rounded

Geology and Physiography: scree-covered hills composed of Paleozoic sedimentary rocks, mostly limestone.
Elevation: 13 to 371 m (43 to 1217 ft)
Soils: mostly dry, rocky soils with no surface organic layer, little ground ice, and a deep (> 1 m) active layer. Soils on vegetated footslopes are probably wetter, with gravel in a loamy matrix, more ground ice, and a thinner active layer. Sorted and nonsorted circles are probably common.
Vegetation/land cover: convex hilltops are bare rock and scree or sparsely vegetated with low shrubs and lichens. Rocky lower slopes have low shrubs. Gentle footslopes have tussock tundra with low shrubs.
Notes:

IHT2 Igichuk Hills, Steep

Geology and Physiography: scree-covered low mountains composed of Paleozoic sedimentary rocks, mostly limestone. Slopes are steeper and ridges narrower than in the preceding unit.
Elevation: 59 to 617 m (194 to 2024 ft)
Soils: mostly dry, rocky soils with no surface organic layer, little ground ice, and a deep (> 1 m) active layer. Soils on vegetated footslopes are probably wetter, with gravel in a loamy matrix, more ground ice, and a thinner active layer.
Vegetation/land cover: mostly convex hilltops with bare rock and scree, and some sparse low shrubs and lichens. Rocky lower slopes have low shrubs. Small areas of tussock and low shrub tundra on gentle footslopes.
Notes:

IHT3 Igichuk Pediment, Tundra

Geology and Physiography: rounded hills mantled with colluvium from Paleozoic sedimentary rocks, probably mostly limestone. Bedrock outcrops are present on some hill crests but are not extensive. Bedrock is probably present within a few meters of the surface on most convex and planar surfaces. Slopes are gentler and may by covered by glacial till in the far south.
Elevation: 3 to 356 m (10 to 1168 ft)
Soils: probably moderately wet, loamy soils with gravel; the active layer is probably about 1 m thick or less in most places and surface organic horizon present but probably 20 cm or less. Some convex hill crests probably have gravelly soils with a deeper active layer (> 1 m) and thin or no organic surface horizon. Mudboils (nonsorted circles) are probably common.
Vegetation/land cover: gentle, convex slopes have tussock and open low shrub tundra, with low shrubs more abundant on north-facing slopes. Drainages have closed low shrubs.
Notes: pediments are slopes with a thin veneer of colluvial deposits (unconsolidated material moving downslope) over bedrock. The colluvium is derived from hill crests where bedrock extends into the active layer (over most of this unit the bedrock is permanently frozen). Colluvium is also derived from adjacent bedrock outcrops in the Igichuk Hills units. For a discussion of pediments in the arctic see French and Harry (1992). This pediment is dissected by small drainages that accumulate deep snowdrifts that persist well into the summer.

IHT4 Kakagrak Hills

Geology and Physiography: steep hills with rounded summits, composed of Paleozoic sedimentary rocks, probably mostly limestone. Extensive scree deposits and bedrock exposures.
Elevation: 26 to 271 m (85 to 889 ft)
Soils: mostly dry, coarse-grained soils with little or no organic surface horizon and deep active layer (> 1 m). Bedrock is probably near the surface on shoulders and summits of slopes. On convex, lower slopes soils are wetter, have an organic surface layer, and the active layer is thinner. Soils here probably consist of gravel in a loamy matrix.

Vegetation/land cover: convex hillslopes and summits are unvegetated rock and scree or sparsely vegetated with dwarf shrubs and lichens. Drier lower slopes have denser shrub cover. Concave lower slopes are low shrub and tussock tundra.
Notes:

IMP Imikruk Plain Subsection

The Imikruk Plain Subsection. Numerous shallow thermokarst depressions are present. Some drained depressions have pingos (ice-cored mounds); a pingo is visible just below the largest lake in the left background, and another just below and to the right of a circular pond in the right-center background. Vegetation is mostly wet sedge, cottonsedge tussock tundra, and low shrubs. July 10, 2001; roll 5, frame 27

Detailed ecological unit in the Imikruk Plain Subsection:
IMP1 Imikruk Plain - 18 km^2
(area within the Monument boundaries)

IMP1 Imikruk Plain

Geology and Physiography: nearly level region of find-grained sediments with numerous thermokarst lakes in various stages of growth, drainage, and succession after drainage. Sediments consist of old coastal marine deposits, probably mostly fine-grained and reworked in thermokarst lakes.
Elevation: 0 to 29 m (0 to 95 ft)
Soils: wet, fine-grained soils with a thick organic surface layer and permafrost within 0.5 m of the surface predominate. The organic layer is thinner and the active layer is temporarily thicker in recently drained lake basins. Ice-wedge polygons are probably common.
Vegetation/land cover: mostly wet herbaceous vegetation. Drier, convex areas between depressions have tussock and low shrub tundra.
Notes: the thaw lake cycle has been studied on the North Slope by Black and Barksdale (1949), Black (1969) and Tedrow (1969). The lakes basins on the Imikruk Plain are not oriented by wind action like the North Slope lakes, but otherwise processes are probably similar. The lake basins form by subsidence due to thaw of ground ice, a process that is enhance by absorption of solar heat by the lake itself. At some point

the lake basin is breached and drains out through the local network of small creeks. Then the lake bottom revegetates and sediments re-freeze. Formation of new ground ice and upward heave of the surface sets the stage for the cycle to occur again.

JDL Jade Lowland Subsection

The Jade Lowland Subsection. This is a region of gentle slopes covered by cottonsedge and low shrub tundra. July 10, 2001; roll 5, frame 4.

Detailed ecological unit in the Jade Lowlands Subsection:
JDL1 Jade Lowland - 187 km^2
(area within the Monument boundaries)

JDL1 Jade Lowland

Geology and Physiography: very gently sloping hills dissected by small streams. Geology uncertain; may include old glacial outwash (Karlstrom *et al.*, 1964), old glacial till, loess, and colluvium from Paleozoic sedimentary rocks.

Elevation: 10 to 243 m (33 to 797 ft)

Soils: probably moderately wet, loamy soils with active layer about 1 m thick or less and surface organic horizon present but probably 20 cm or less in most places. Mudboils (nonsorted circles) are probably common.

Vegetation/land cover: long, gentle slopes have mostly open low shrub and tussock tundra. Closed low shrub occurs along drainages and wet herbaceous vegetation in some depressions.

Notes: the old glacial outwash mapped in this area by Karlstrom *et al.* (1964) was not distinguishable on aerial photographs. The gentle, well dissected topography suggests that the deposits are quite old.

KBL Krusenstern-Sheshalik Beaches and Lagoons Subsection

The Krusenstern-Sheshalik Beaches and Lagoons Subsection. The open ocean in the background and outside of the photo to the left. Numerous old beach ridges parallel the active beach, with the oldest beaches on the right (inland) side). Long, narrow ponds lie in between the beach ridges, with older ponds enlarged by thermokarst. Krusenstern Lagoon is visible in the upper right. July 10, 2001; roll 4, frame 28.

Detailed ecological unit in the Krusenstern-Sheshalik Beaches and Lagoons Subsection:
KBL1 Krusenstern-Sheshalik Beaches and Lagoons - 177 km^2
(area within the Monument boundaries)

KBL1 Krusenstern-Sheshalik Beaches and Lagoons

Geology and Physiography: the side of this unit nearest the ocean consists of numerous gravelly beach ridges roughly parallel to modern beach; beaches increase in age as one moves inland (Giddings, 1966; Giddings and Anderson, 1986). The inland side of this unit consists fine-grained alluvium and shallow-water marine sediments deposited in lagoons and deltas. Topography is nearly level except for the beach ridges. Numerous lakes and ponds, largely of thermokarst origin, occur in older beach deposits and deltaic sediments. This unit includes one large lagoon (Krusenstern), one small lagoon (Aukulak), and a lagoon-like region behind Sheshalik Spit. Lakes, ponds, and lagoon are probably brackish due to mixing of precipitation water, river water, and seawater.

Elevation: 0 to 15 m (0 to 49 ft)

Soils: dry, gravelly soils with thick (>1 m) active layer on beach ridges. Organic surface layers are present between older beach ridges (Plug and Mann, 1995). Soils in finer sediments of deltas along rivers are probably wet, with a thinner active layer, higher ice content, and a surface organic horizon.

Vegetation/land cover: active beaches are barren or sparsely vegetated. Beach ridges further inland have mostly low or dwarf shrubs and dry to moist herbaceous vegetation. On finer-grained soils in the vicinity of tidal channels and thermokarst ponds, vegetation includes wet herbaceous, tussock tundra, and closed low shrubs.

Notes: beaches consist of gravel and cobbles transported from rock outcrops to the north and west. For a discussion of the geomorphology of beach ridges, see Moore (1966), Mason (1990) and Mason and Ludwig (1990). Aukulak Lagoon appears to have steep banks and appears to have originated by both wave action and thaw of landward sediments. Freshwater streams empty into the lagoons, so water is probably brackish.

KKL Kivalina-Kotlik Lagoons and Beaches Subsection

Kivalina-Kotlik Lagoons and Beaches. The Chukchi Sea is at the very bottom of the photograph, with the active beach and vegetated beach ridge separating it from the lagoon behind. The Delta of the Omikviorok River is at the back of the lagoon. July 10, 2001; roll 5, frame 30.

Detailed ecological unit in the Kivalina-Kotlik Lagoons and Beaches Subsection:
KKL1 Kivalina-Kotlik Lagoons and Beaches - 40 km^2
(area within the Monument boundaries)

KKL1 Kivalina-Kotlik Lagoons and Beaches

Geology and Physiography: a narrow gravelly beach ridge with lagoons of various sizes to the landward side. Fine-grained deltaic and lagoon sediments on the landward sides of lagoons. Lagoons are probably brackish due to mixing of seawater of freshwater from streams that empty into the lagoons.

Elevation: 0 to 15 m (0 to 49 ft)

Soils: dry, gravelly soils with thick (>1 m) active layer on beach ridges. Soils in finer sediments of deltas along rivers are probably wet, with a thinner active layer, higher ice content, and may have a surface organic horizon

Vegetation/land cover: sparsely vegetated on active beach ridges and tidal mud flats; wet herbaceous and low shrubs on delta deposits of the inland side.

Notes: beaches consist of gravel and cobbles transported from rock outcrops to the north and west. For a discussion of the geomorphology of beach ridges, see Moore (1966). Lagoons appears to have originated by both wave action and thaw of landward sediments. The largest lagoon (Kivalina) is outside of the study area to the northwest. Some of the polygons delineated here are smaller than normal for a subsection; they are placed in KKL rather than the adjacent coastal plain so that all the coastal lagoons on the Chukchi Sea are together in one unit.

KOP Kotlik Coastal Plain Subsection

Kotlik Coastal Plain Subsection. Note ice-wedge polygons in the foreground and remnant shore of an old large thermokarst lake curving across the center of the photo. Smaller thermokarst lakes and the Chukchi Sea are in the background. Vegetation is mostly wet sedge or cottonsedge tundra. July 10, 2001; roll 4, frame 31.

Detailed ecological units in the Kotlik Coastal Plain Subsection:

KOP1 Kilikmak Creek Floodplain - 7 km^2
KOP2 Kotlik Coastal Plain - 123 km^2
KOP3 Rabbit Creek Floodplain - 17 km^2
(areas within the Monument boundaries)

KOP1 Kilikmak Creek Floodplain

Geology and Physiography: floodplain and young terraces of a small meandering river. Sediment probably mostly derived from limestone. Numerous wet depressions, some obviously oxbows and some not, occur along the margin of the floodplain below the footslope of the adjacent uplands.

Elevation: 2 to 74 m (7 to 243 ft)

Soils: soils are highly variable depending on proximity to the river, age of the surface, and vegetation. Soils appear mostly quite wet and probably consist of stratified mineral and organic layers. Well-drained, coarse-grained soils with a deep active layer are probably present locally on and near active gravel bars.

Vegetation/land cover: mostly wet herbaceous and open low shrub vegetation. Sparsely vegetated gravel bars occur on the inside of meander bends.

Notes: includes one prominent icing (aufeis) field centered near 67° 19'N, 163° 30'W. For general information on icings, see Carey (1973). This floodplain is wetter and has less sparse vegetation on gravelly soils than the nearby Rabbit Creek Floodplain.

KOP2 Kotlik Coastal Plain

Geology and Physiography: nearly level region with numerous thermokarst lakes in various stages of growth, drainage, and succession after drainage. Sediments consist of old coastal marine deposits, probably mostly fine-grained and reworked in thermokarst lakes.

Elevation: 0 to 60 m (0 to 197 ft)

Soils: wet, fine-grained soils with a thick organic surface layer and permafrost within 0.5 m of the surface predominate. The organic layer is thinner and the active layer is temporarily thicker in recently drained

lake basins. A thinner organic surface also probably present on slightly convex surfaces between lakes. Ice-wedge polygons are probably common.

Vegetation/land cover: slightly higher, convex areas have tussock and low shrub tundra. Depressions have mostly wet sedge vegetation.

Notes: See Imikruk Plain for information on the thaw lake cycle.

KOP3 Rabbit Creek Floodplain

Geology and Physiography: floodplain and young terraces of a small meandering river. Sediment probably mostly derived from sandstone and graywacke.

Elevation: 0 to 117 m (0 to 384 ft)

Soils: soils are highly variable depending on proximity to the river, age of the surface, and vegetation. Well-drained, coarse-grained soils with a deep active layer are probably present on and near active gravel bars. Successively older and higher surfaces should have finer-grained and wetter soils with permafrost near the surface and some surface organic layer.

Vegetation/land cover: sparsely vegetated on active gravel bars, and mostly closed low or tall shrubs on more stable surfaces. Open low shrubs in some places further from active river channels.

Notes: Includes one large icing (aufeis) field centered near 67° 28'N, 163° 48'W. A smaller icing field is located near 67° 32.5'N 163° 31.5W. For general information on icings, see Carey (1973).

LNM Lower Noatak Moraine Subsection

The Lower Noatak Moraine Subsection. Some parts are more sloping and dissected by small streams (foreground) while others are flatter and have thermokarst lakes (background). Vegetation is mostly tussock tundra on higher areas, with low shrubs (darker green) along drainages. (Dark areas in middle background are cloud shadows.) July 10, 2001; roll 5, frame 6.

Detailed ecological units in the Lower Noatak Moraine Subsection:

LNM1 Lower Noatak Moraine, Dissected - 44 km^2

LNM2 Lower Noatak Moraine, Thermokarsted - 54 km^2

(areas within the Monument boundaries)

LNM1 Lower Noatak Moraine, Dissected

Geology and Physiography: gentle mostly east-facing footslope of the Mulgrave and Igichuk Hills. Composed of old glacial deposits, dissected by a dense network of small ephemeral streams.

Elevation: 26 to 171 m (85 to 561 ft)

Soils: mostly moderately wet, loamy soils with active layer about 1 m thick or less and a surface organic horizon. Possibly some drier soils with thicker active layer and more coarse fragments on convexities. Mudboils (nonsorted circles) are probably common.

Vegetation/land cover: mostly low shrub and tussock tundra, with closed low shrubs along drainageways. Shrubs are denser in the northeastern part and form some large stands on seepage slopes; this area also has some spruce woodland.

Notes: this moraine was deposited by a glacier that advanced down the Noatak Valley. The terminus of this glacier was along the northwest edge of this map unit. The moraine is old, so morainal topography has been destroyed by erosion and deposition, identification of the moraine by aerial photography is uncertain, and the western limit of the moraine is speculative. The limit of the moraine mapped here generally follows Karlstrom *et al*. (1964) and is differentiated from the Jade Lowland to the west by the slightly more hummocky topography of the moraine.

LNM2 Lower Noatak Moraine, Thermokarsted

Geology and Physiography: undulating plain composed of old glacial deposits.

Elevation: 24 to 89 m (79 to 292 ft)

Soils: mostly moderately wet, loamy soils with active layer about 1 m thick or less and a surface organic horizon. Locally drier soils with thicker active layer and more coarse fragments on convex hill crests. Wetter soils in depressions. Mudboils (nonsorted circles) are probably common.

Vegetation/land cover: mostly low shrub and tussock tundra, with wet herbaceous vegetation in some depressions and closed low shrubs along drainageways.

Notes: this moraine was deposited by a glacier that advanced down the Noatak Valley. The terminus of this glacier was along the west edge of this map unit. The moraine is old, and the western limit of the moraine is speculative. The limit of the moraine mapped here generally follows Karlstrom *et al*. (1964) and is differentiated from the Jade Lowland to the west mainly by the abundance of lakes. Present-day lakes appear to be mainly of thermokarst origin, although some may have persisted from earlier kettle lakes.

MLH Mulgrave Hills Subsection

The Mulgrave Hills Subsection. (Upper photo) This portion of the Subsection, the Tahinichok Mountains, has tussock and low shrub tundra in low areas and bedrock (sandstone, graywacke, conglomerate) exposed on hilltops. Late-lying snowbanks occur along drainages and on lee sides of hills. July 10, 2001; roll 5, frame 32. (Lower photo) This portion of the Subsection, the Mulgrave Pediment, is sloping tussock and low shrub tundra with little exposed bedrock; late-lying snowbanks are common along drainages and lee sides of hills. July 10, 2001; roll 5, frame 16.

Detailed ecological units in the Mulgrave Hills Subsection:

MLH1 Alutunitok Hills - 26 km^2

MLH2 Kikmiksok Mountain - 6 km^2
MLH3 Mulgrave Hills - 148 km^2
MLH4 Mulgrave Pediment - 355 km^2
MLH5 Mulgrave Pediment/Footslope - 143 km^2
MLH6 Tahinichok Mountains - 107 km^2
(areas within the Monument boundaries)

MLH1 Alutunitok Hills

Geology and Physiography: mostly rounded hills composed of Paleozoic sedimentary rocks, probably mostly limestone. Summits mostly flat or rounded, with some steep scree slopes.
Elevation: 74 to 352 m (243 to 1155 ft)
Soils: sparsely vegetated areas have dry, rocky soils with a thick (> 1 m) active layer. Vegetated lower slopes probably have loamy soils with considerable rock fragments and an organic surface layer is present but not thick (< 20 cm). The latter soils are wetter and have a thinner active layer, probably 0.5 to 1.5 m. Both sorted and nonsorted circles are probably present.
Vegetation/land cover: convex hilltops are bare rock and scree or sparsely vegetated with low shrubs and lichens. Lower slopes have tussock tundra with low shrubs. Lines of closed low shrub occurs along drainageways.
Notes:

MLH2 Kikmiksok Mountain

Geology and Physiography: rounded low mountains composed of clastic Paleozoic sedimentary rocks, probably sandstone, graywacke,and conglomerate.
Elevation: 261 to 688 m (856 to 2257 ft)
Soils: bedrock outcrops and dry, rocky soils with a thick (> 1m) active layer and little or no organic surface horizon predominate on convex mountain slopes and crests. Wetter soils with a thinner active layer, perhaps 0.5 to 1.5 m, and a thin (< 20 cm) organic surface horizon probably dominate the conave lower slopes. Mudboils (nonsorted circles) are probably common.
Vegetation/land cover: vegetated rock and scree sparsely vegetated with dwarf shrubs and lichens occurs on convex slopes and crests. Dwarf shrub and tussock tundra occur on concave lower slopes.
Notes: late-lying snowbanks occur on northwest-facing shoulder slopes and in drainage ravines.

MLH3 Mulgrave Hills

Geology and Physiography: hills composed of Paleozoic sandstone, graywacke, and conglomerate.
Elevation: 80 to 473 m (262 to 1552 ft)
Soils: convex areas have well-drained, coarse-grained, gravelly soils with a thick active layer, and some bedrock outcrops. Sorted patterned ground is probably common. Concave areas probably have wet soils and permafrost within 1.5 m of the surface. Textures are probably loamy with gravel present near the rocky convexities. Mudboils (nonsorted circles) are probably common.
Vegetation/land cover: hill crests have dry herbaceous or open dwarf shrub vegetation. Slopes have mostly tussock and open low shrub tundra. Drainageways have closed low shrub vegetation.
Notes: this region has gentler topography than the Tahinichok Mountains and less area covered by sparsely vegetated convexities with rocky soils. Late-lying snowbanks are common on the north and northwest sides of hills, and in small drainages.

MLH4 Mulgrave Pediment

Geology and Physiography: rounded hills mantled with colluvium from clastic Paleozoic sedimentary rocks, probably mostly sandstone and graywacke, with a little limestone in the southeast. Bedrock outcrops are present on some hill crests but are not extensive. Bedrock is probably present within a few meters of the surface on most convex and planar surfaces.
Elevation: 80 to 426 m (262 to 1398 ft)
Soils: probably moderately wet, loamy soils with gravel; the active layer is probably about 1 m thick or less in most places and surface organic horizon present but probably 20 cm thick or less. Some convex hill crests probably have gravelly soils with a deeper active layer (> 1 m) and thin or no organic surface horizon. Mudboils (nonsorted circles) are probably common.

Vegetation/land cover: gentle convex slopes have open low shrub and tussock tundra. Drainageways have closed low or tall shrub vegetation. Some hill crests have dry herbaceous vegetation.

Notes: pediments are slopes with a thin veneer of colluvial deposits (unconconsolidated material moving downslope) over bedrock. The colluvium is derived from hill crests where bedrock extends into the active layer (over most of this unit the bedrock is permanently frozen). For a discussion of pediments in the arctic see French and Harry (1992). This pediment is dissected by small drainages that accumulate deep snowdrifts that persist well into the summer.

MLH5 Mulgrave Pediment/Footslope

Geology and Physiography: rounded hills and mantled with colluvium from clastic Paleozoic sedimentary rocks, probably mostly sandstone and graywacke. Also, colluvial slopes below the Tahinichok Mountains. Bedrock outcrops are present on some hill crests but are not extensive. Bedrock is probably present within a few meters of the surface on most convex and planar surfaces.

Elevation: 12 to 228 m (39 to 748 ft)

Soils: probably moderately wet, loamy soils with gravel; the active layer is probably about 1 m thick or less in most places and surface organic horizon present but probably 20 cm thick or less. Some convex hill crests probably have a deeper active layer (> 1 m). Mudboils (nonsorted circles) are probably common.

Vegetation/land cover: gentle convex slopes have open low shrub and tussock tundra. Drainageways have closed low or tall shrub vegetation. Some hill crests have dry herbaceous vegetation.

Notes: pediments are slopes with a thin veneer of colluvial deposits (unconconsolidated material moving downslope) over bedrock. The colluvium is derived from hill crests where bedrock extends into the active layer (over most of this unit the bedrock is permanently frozen). For a discussion of pediments in the arctic see French and Harry (1992). This unit is lower and more gently sloping than the adjacent and similar Mulgrave Pediment. It also includes colluvial slopes below the the Tahinichok Mountains where colluvium could be quite thick.

MLH6 Tahinichok Mountains

Geology and Physiography: rounded low mountains composed of Paleozoic sandstone, graywacke, and conglomerate.

Elevation: 66 to 494 m (217 to 1621 ft)

Soils: convex areas have well-drained, coarse-grained, gravelly soils with a thick active layer, and some bedrock outcrops. Sorted patterned ground is probably common here. Concave areas probably have wet soils and permafrost within 1.5 m of the surface. Textures are probably loamy with gravel present. Mudboils (nonsorted circles) are probably common on the concave areas.

Vegetation/land cover: convex mountain slopes and crests are sparsely vegetated rock and scree or have open dwarf shrub vegetation. Denser dwarf shrubs occur on lower but still dry and rocky slopes. Gentle concave lower slopes have tussock or low shrub tundra, with closed low shrubs along drainageways.

Notes: late-lying snowbanks are common on the north and northwest sides of hills, and in small drainages.

NOD Noatak Delta Subsection

The Noatak Delta Subsection. Tidal mudflats are visible on the right, with areas of wet herbaceous vegetation to left. The main channel of the Noatak River is in background, with minor distribuary channels meandering from the river to Kotzebue Sound (behind the photographer). July 10, 2001; roll 4, frame 4.

Detailed ecological unit in the Noatak Delta Subsection:

NOD Noatak Delta - 1 km^2
(area within the Monument boundaries)

NOD Noatak Delta

Geology and Physiography: nearly level, fine-grained alluvium and shallow-water marine deposits.
Elevation: 0 to 11 m (0 to 36 ft)
Soils: mostly wet and fine-grained. Saline in distal portions most affected by seawater. The younger (distal) portions probably have little organic surface layer and probably have permafrost. Older surfaces probably have a substantial organic surface layer or stratified organic and fine-grained mineral matter, with permafrost and a thin (0.5 m) active layer.
Vegetation/land cover: unvegetated mud flats, low shrubs, wet herbaceous vegetation, and considerable open water.
Notes: only two very small areas of this unit occur in the study area. The unit is extensive outside of the study area to the east. Lakes increase in abundance in the older (proximal, northern and eastern) parts of the Delta. This is probably due to the accumulation of ground ice in these older sediments and consequent thermokarst.

WUL Wulik Lowland Subsection

The Wulik Lowland Subsection. This lowland includes areas with thermokarst lakes, such as the one on the right of this photo, and areas dissected by small streams with few lakes (background). Note the former larger extent of the lake (marked by brighter green vegetation to the left and below the present ponds), and the outlet stream from it upper left side. July 10, 2001; roll 5, frame 21.

Detailed ecological units in the Wulik Lowland Subsection:

WUL1 Omikviorok River Floodplain - 24 km^2
WUL2 Wulik Dissected Plain - 202 km^2
WUL3 Wulik Lowland - 149 km^2
(areas within the Monument boundaries)

WUL1 Omikviorok River Floodplain

Geology and Physiography: nearly level floodplain of a meandering river and its tributaries. All parts subject to at least rare flooding or riverbank erosion.

Elevation: 0 to 66 m (0 to 217 ft)

Soils: soils are highly variable depending on proximity to the river, age of the surface, and vegetation. Well-drained, coarse-grained soils with a deep active layer are probably present on and near active gravel bars. Successively older and higher surfaces should have wetter soils with permafrost near the surface and some surface organic layer.

Vegetation/land cover: mostly closed low shrubs, with some tall closed shrubs. Shrubs less dense in less frequently flooded areas further from river channels. Wet herbaceous vegetation in some depressions and sparsely vegetated on active gravel bars.

Notes: Includes one large icing (aufeis) field centered near 67° 41'N, 164° 5'W. For general information on icings, see Carey (1973).

WUL2 Wulik Dissected Plain

Geology and Physiography: gently sloping lowland underlain by old glacial deposits, possibly as a thin veneer over bedrock. Drained by a network of slightly incised small streams.

Elevation: 26 to 235 m (85 to 771 ft)

Soils: probably mostly rather wet, loamy soils with a active layer about 1 m thick or less and surface organic layer present but less than 30 cm thick.

Vegetation/land cover: mostly open low shrub and tussock tundra. Closed shrubs and some wet herbaceous vegetation in drainageways. Mudboils (nonsorted circles) are probably common.

Notes: drainage is organized into narrower, more distinct drainageway than in the Wulik Lowland. The western limit of old glacial moraine and associated outwash deposit shown by Karlstrom et al. (1964) in this area could not be distinguished on our air photographs or satellite images.

WUL3 Wulik Lowland

Geology and Physiography: gently sloping lowland underlain by old glacial deposits. Drained by a parallel series of broad seepage hollows.

Elevation: 0 to 197 m (0 to 646 ft)

Soils: mostly wet soils with loamy textures and permafrost within 1.5 m of the surface. Depressions probably contain organic soils with polygonal patterned ground and permafrost within 0.5 m of the surface.

Vegetation/land cover: seepage hollows and depressions contain mostly wet herbaceous vegetation. Gently convex surfaces between the seepage hollows have mostly low shrub, tussock, or moist herbaceous tundra vegetation.

Notes: regional slope is to northwest, and small streams and hollows that carry seepage are oriented in this direction. Thermokarst has caused a series of depressions to form along these drainage lines, some containing lakes and others containing peat with numerous small ponds. For general information on this type of peatland (polygonal peat plateau) see Zoltai and Tarnocai (1975). The western limit of old glacial moraine and associated outwash deposit shown by Karlstrom et al. (1964) in this area could not be distinguished on our air photographs or satellite images.

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Tables

Table 1. National Hierarchical Framework of Ecological Units*

Ecoregion (<1:5,000,000)
Subregion
  Section (1:7,500,000 to 1:3,500,000)
  Subsection (1:3,500,000 to 1:250,000)
Landscape
  Landtype association (1:250,000 to 1:60,000)
Land unit
  Landtype (1:60,000 to 1:24,000)
  Landtype phase (>1:24,000)

*from Cleland *et al.*, 1997; typical mapping scales for each level are given in parentheses

Table 2: Index to the Ecological Units of Cape Krusenstern National Monument

Subsection		**Detailed Ecological Unit**	
Symbol	***Name***	***Symbol***	***Name***
ACP	Aukulak Coastal Plain	ACP1	Aukulak Coastal Plain
IGL	Igisukruk Lowland	IGL1	Igisukruk Creek Floodplain
		IGL2	Igisukruk Lowland
IHF	Igichuk Hills, forest-tundra	IHF1	Igichuk Pediment, Forest-Tundra
IHT	Igichuk Hills, tundra	IHT1	Igichuk Hills, Rounded
		IHT2	Igichuk Hills, Steep
		IHT3	Igichuk Pediment, Tundra
		IHT4	Kakagrak Hills
IMP	Imikruk Plain	IMP1	Imikruk Plain
JDL	Jade Lowland	JDL1	Jade Lowland
KBL	Krusenstern-Sheshalik Beaches and Lagoons	KBL1	Krusenstern-Sheshalik Beaches and Lagoon
KKL	Kivalina-Kotlik Lagoons and Beaches	KKL1	Kivalina-Kotlik Lagoons and Beaches
KOP	Kotlik Coastal Plain	KOP1	Kilikmak Creek Floodplain
		KOP2	Kotlik Coastal Plain
		KOP3	Rabbit Creek Floodplain
LNM	Lower Noatak Moraine	LNM1	Lower Noatak Moraine, Dissected
		LNM2	Lower Noatak Moraine, Thermokarsted
MLH	Mulgrave Hills	MLH1	Alutunitok Hills
		MLH2	Kikmiksok Mountain
		MLH3	Mulgrave Hills
		MLH4	Mulgrave Pediment
		MLH5	Mulgrave Pediment/Footslope
		MLH6	Tahinichok Mountains
NOD	Noatak Delta	NOD	Noatak Delta
WUL	Wulik Lowland	WUL1	Omikviorok River Floodplain
		WUL2	Wulik Dissected Plain
		WUL3	Wulik Lowland

Table 3. Summary of Criteria Used to Delineate Subsections in Cape Krusenstern National Monument

Subsection	Summary of Delineation Criteria
ACP - Aukulak Coastal Plain	Coastal plain composed of Quaternary marine and glacial deposits, with numerous thaw-lakes. Resembles KOP but is further south and faces Kotzebue Sound rather than the Chukchi Sea.
IGL - Igisukruk Lowland	Gentle hills composed of old Quaternary glacial deposits and colluvium from limestone hills. Gentler slopes and wetter soils than the adjacent IHT and IHF units.
IHF - Igichuk Hills, forest-tundra	Rounded limestone hills mantled with colluvium. Resembles unit IT, but has patches of trees on favorable sites, indicating warmer summers and/or less windy winters.
IHT - Igichuk Hills, tundra	Low mountains and hills composed of limestone, and adjacent pediments. Resembles unit IF but is located west of treeline, indicating a colder climate.
IMP - Imikruk Plain	Coastal plain composed of Quaternary marine deposits; floodplains of small rivers, and thaw-lake plains. Resembles unit KOP but is farther north, has more surface water and is larger (it extends well outside of the monument to the northwest).
JDL - Jade Lowland	Gentle hills and plains composed of old Quaternary glacial deposits, loess, and colluvium from sedimentary rocks. Resembles unit IGL but is located north of the Igichuk Hills. Also resembles unit LNM but generally slopes toward the Chukchi Sea and is beyond the glacial limit.
KBL - Krusenstern-Sheshalik Beaches and Lagoons	Beach ridges, lagoons, and deltas of small streams along Kotzebue Sound. Differentiated from the adjacent coastal plain by the presence of salty or brackish (as opposed to fresh) water and/or sedimentation by the present-day ocean. Resembles unit KKL but has a wide complex of beach ridges (Cape Krusenstern), faces Kotzebue Sound rather than the Chukchi Sea, and will probably be placed in a different Ecoregion.
KKL - Kivalina-Kotlik Lagoons and Beaches	Beach ridges, lagoons, and deltas of small streams along the Chukchi Sea. Differentiated from the adjacent plains by the presence of salty or brackish (as opposed to fresh) water and/or sedimentation by the present-day ocean. Resembles unit KBL but faces the Chukchi Sea rather than Kotzebue Sound, and will probably be placed in a different Ecoregion
KOP - Kotlik Coastal Plain	Coastal plain composed of Quaternary marine deposits and alluvium; includes small river floodplains and thaw-lake plains. Resembles unit ACP but was not glaciated, is farther north, faces the Chukchi Sea rather than Kotzebue Sound, and will probably be placed in a different Ecoregion.
LNM – Lower Noatak Moraine	Gentle slopes composed of old glacial deposits in the Noatak River valley.
MLH - Mulgrave Hills	Low mountains and hills composed mostly of clastic sedimentary rocks, and adjacent pediments.
NOD - Noatak Delta	Alluvial and marine sediments in the Noatak Delta. Influenced by tidewater, unlike the floodplain that adjoins it from above.
WUL - Wulik Lowland	Gently sloping lowland composed of old glacial deposits. Drainage is better than the adjacent Imikruk Plain and there are few thaw lakes. Resembles unit JDL but is located north of the Mulgrave Hills.

Table 4. Land Cover Composition and Area of the Ecological Subsections, Cape Krusenstern NM*

Ecological Subsection Symbol (see Table 2)	Area occupied by each land cover class, in % of the ecological unit																		Ecological Unit Area as % of Monument	Area of Ecological Unit, km^2
	Closed needleleaf forest	Open needleleaf forest	Needleleaf woodland	Tall open and closed alder/willow	Closed low shrub - alder/willow	Closed low shrub - birch/ericaceous	Open low shrub - alder/willow	Open low shrub - birch/ericaceous	Open low and dwarf shrub tussock tundra	Dwarf shrub tundra/dwarf shrub peatland	Open dwarf shrub - talus/lichen	Moist or dry herbaceous	Wet herbaceous	Sparsely vegetated	Barren	Clear water	Turbid water	Shadow		
ACP	-	-	-	2	5	2	8	41	18	5	4	1-	1	-	-	4	-	-	4	114
IGL	-	1	1	3	1	1	18	57	14	2	-	1	-	-	-	-	-	-	2	52
IHF	1	3	1	9	3	7	19	29	15	6	-	3	1	1	1	-	-	-	3	81
IHT	-	-	-	2	2	4	3	21	28	1-	6	9	1	5	11	-	-	-	22	600
IMP	-	-	-	3	1	2	2	17	16	-	-	22	27	-	-	1-	-	-	1	18
JDL	-	-	-	3	1	9	1	57	15	-	-	1-	2	-	-	-	-	-	7	187
KBL	-	-	-	-	2	-	3	2	3	3	2	8	3	-	1	70	1	-	7	177
KKL	-	-	-	1	1	-	2	4	2	-	2	1	10	1	-	72	3	-	1	40
KOP	-	-	-	3	2	3	5	31	24	2	4	8	11	-	-	5	1	-	6	147
LNM	-	-	-	4	2	4	3	53	15	-	2	8	5	-	-	4	1	-	4	97
MLH	-	-	-	7	6	8	1	30	25	3	2	15	2	1	-	-	-	-	29	785
NOD	-	-	-	-	3	-	14	3	-	-	-	1	2	-	7	67	-	-	0	1
WUL	-	-	-	6	2	8	1	47	15	-	1	12	6	-	-	1	-	-	14	375
All	-	-	-	4	3	6	3	32	2-	4	3	11	3	1	3	7	-	-	100	2673

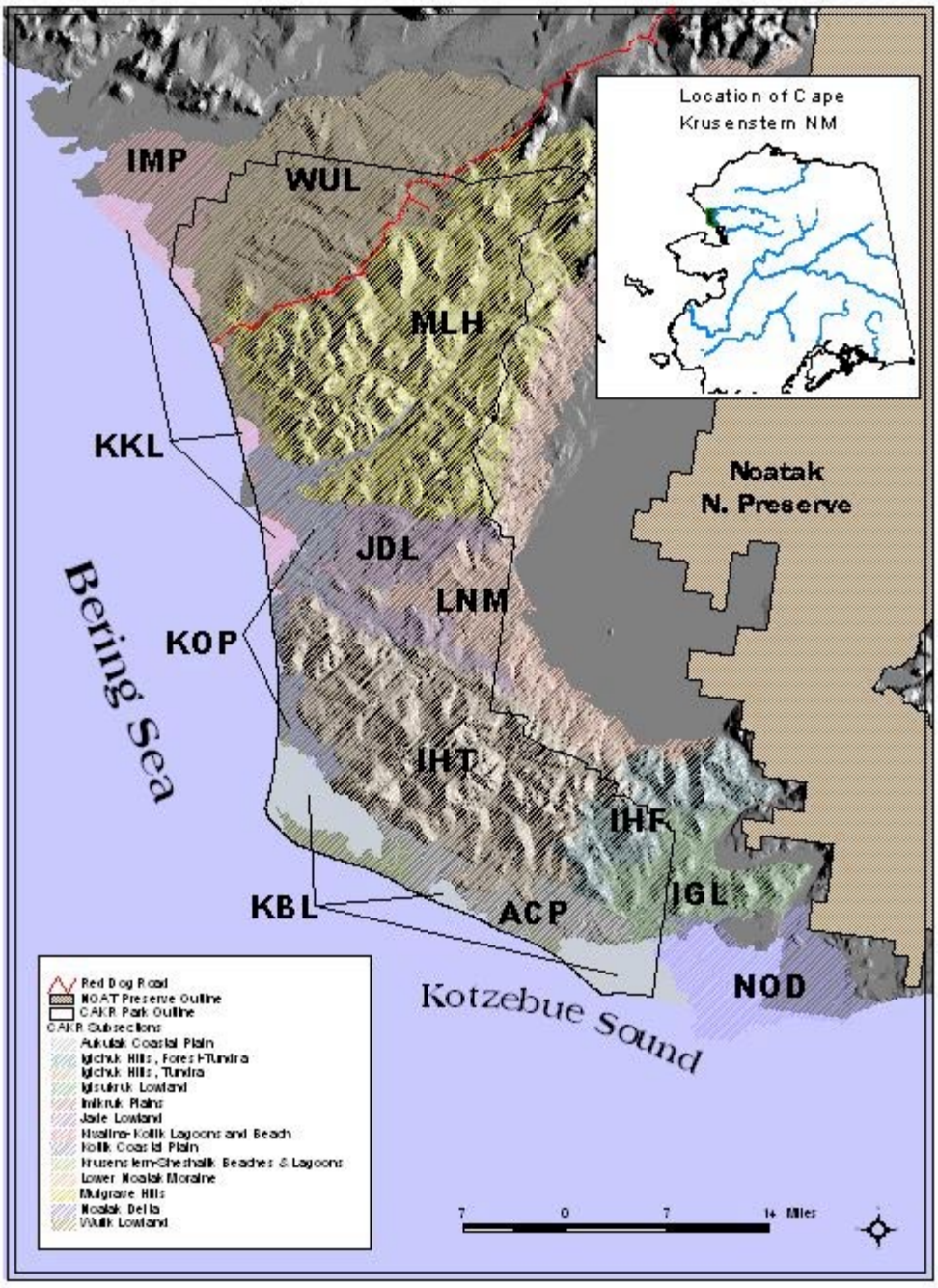
**Dash indicates less than 0.5%. Land cover is based on a map by Markon and Wesser (1998). For Subsections that extend outside of the Monument, only the part within the Monument boundaries is analyzed here.*

Table 5. Temperature and Precipitation Summary for Kotzebue, Alaska

Month	avg daily max	avg daily min	avg	2 yrs in 10 will have max temp. greater than	2 yrs in 10 will have min temp. less than	avg # of grow deg days*	avg	avg # of days less than	2 yrs in 10 will have avg days more than	w/.1 or more	total snow fall
January	4.2	-8.9	-2.3	34	-40	0	0.44	0.17	0.68	1	6.7
February	2.8	-11.5	-4.3	34	-41	0	0.37	0.14	0.58	0	5.5
March	8.5	-8.3	0.1	35	-36	0	0.36	0.13	0.6	1	5.8
April	21.3	3.5	12.4	42	-24	0	0.38	0.14	0.58	1	5
May	38.4	25	31.7	62	-1	20	0.36	0.11	0.59	1	1.6
June	50.3	38.3	44.3	75	27	168	0.55	0.17	0.86	1	0.1
July	59.2	48.6	53.9	78	36	430	1.43	0.6	2.13	4	0
August	56.5	46.9	51.7	73	34	362	2.12	0.92	3.15	6	0
September	46.7	36.8	41.8	63	21	108	1.6	0.68	2.38	5	1.2
October	27.8	18.4	23.1	46	-6	2	0.8	0.34	1.22	2	6.7
November	13.8	3	8.4	36	-23	0	0.6	0.22	0.91	1	8.8
December	4.4	-8.4	-2	34	-37	0	0.48	0.23	0.69	1	8.1
Yearly:											
Average	**27.8**	**15.3**	**21.6**	—	—	—	—	—	—	—	—
Extreme	**85**	**52**	—	**80**	**44**	—	—	—	—	—	—
Total	—	—	—	—	—	**1090**	**9.49**	**6.89**	**11.55**	**24**	**49.5**

Station: KOTZEBUE WSO AIRPORT, ALASKA Start yr. - 1949 End yr — 1999
Average # of days per year with at least 1 inch of snow on the ground: ***212***
**A growing degree day is a unit of heat available for plant growth. It can be calculated by adding the maximum and minumum daily temperatures, dividing the sum by 2, and subtracting the temperature below which growth is minimal for the principal crops in the area (Threshold : 40.0 deg. F) This climatic summary was computed by USDA Natural Resources Conservation Service CFS/CDAN system from National Weather Service Data.*

Fig. 1. Ecological Subsections of Cape Krusenstern National Monument.



Full names for the symbols and a brief description are given in Table 3.